Panorama Orientation

A Guide for PTGui Users

By V. Kelly Bellis

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See related: *A Study of Panorama Drone Orientation*, https://archive.org/details/a-study-of-panorama-drone-orientation

Panorama Orientation, A Guide for PTGui Users
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Introduction

PTGui[1], a multi-platform panoramic stitching software, is uniquely suited for accurately performing panorama orientation. Beginning with the finished panorama loaded into PTGui, from the Panorama Editor, Projection, reproject by choosing Little Planet: 300° Stereographic. The reasons for choosing this projection are listed below by order of priority:

- Stereographic projections are sometimes also referred to as *Azimuthal Conformal Projection* because it perfectly preserves azimuths radial from the origin; i.e., the center of the panorama, where you've set up your tripod - ***angles measured in the panorama are the same as if measured on the ground***.
- The field of view is automatically set to 300° x 300°. If you had chosen Stereographic Down, which is what's used in making these Little Planets, you'll in either case likely want to adjust the field of view; Panorama Editor, Projection, Field of view:, as best suits you.
- Keeping the horizontal field of view and the vertical field view equal to each other; e.g., 240° x 240°, will make things easier in working with the exported image; specifically, when making angular measurements snapped from the origin.

[1] https://ptgui.com/

Applicability

These directions apply equally to all types of 360° x 180° panoramas including interior and exterior panoramas, terrestrial based sans geotagging, and aerial panos using a drone. In regard to the latter, note that PTGui by default uses the DJI-XMP tag GimbalYawDegree, not the FlightYawDegree tag, for its internal processing. While using the GimbalYawDegree tag, or for that matter the FlightYawDegree tag, may be adequate for the user in many cases for automated orientation, the DJI yaw data remains questionable for consistently and reliably orienting drone panoramas to true north and suggests the need for additional testing across multiple air frames[2].

Preparation

Before measuring any angles, determine what photo-recognizable object in your panorama you'll be using as a basis for orientation to north. For example, if the panorama was shot outdoors, you might choose the sun, a cell tower, or a church steeple. If the panorama was shot indoors, you'll need to identify how the building is oriented and then the best indicator in the pano as it relates to the building's footprint. We'll get into the details and examples for each of these orientation scenarios shortly, but before that, it's important to first embrace 2 disparate methods of measuring direction, both of which will be used; i.e., *azimuths* and *polar angles*.

[2] *A Study of Panorama Drone Orientation*, V. Kelly Bellis, 2026, https://archive.org/details/a-study-of-panorama-drone-orientation

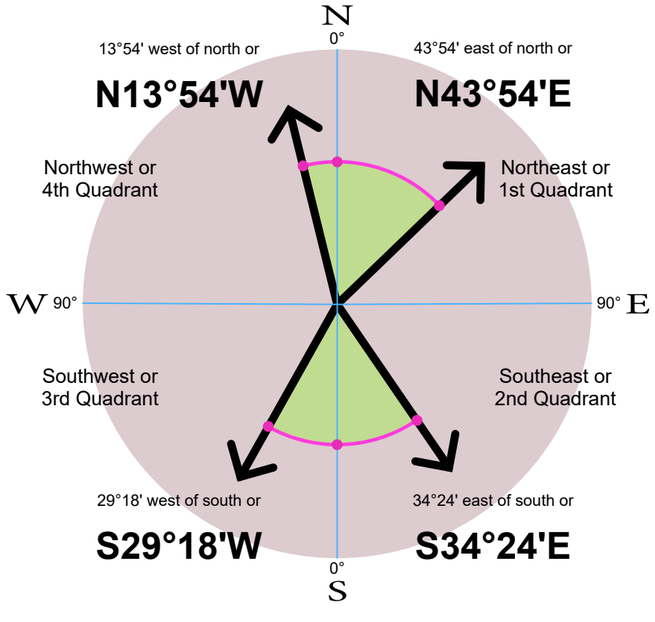
Bearings, azimuths, and polar rays are illustrated below, but to be clear, bearings won't be used in this discussion, even though all too often they're incorrectly given equivalence to azimuths.

Defining the Origin

In all scenarios discussed below, the center of the stereographic projected panorama raster image will need to be defined. It begins with PTGui and a fully stitched and adjusted panorama. It makes no difference if you start with the original .pts multi-image dataset, or a single image equirectangular .jpg that had previously been exported from PTGui, or the one produced by the DJI Fly app. For this discussion, we'll use the latter approach.

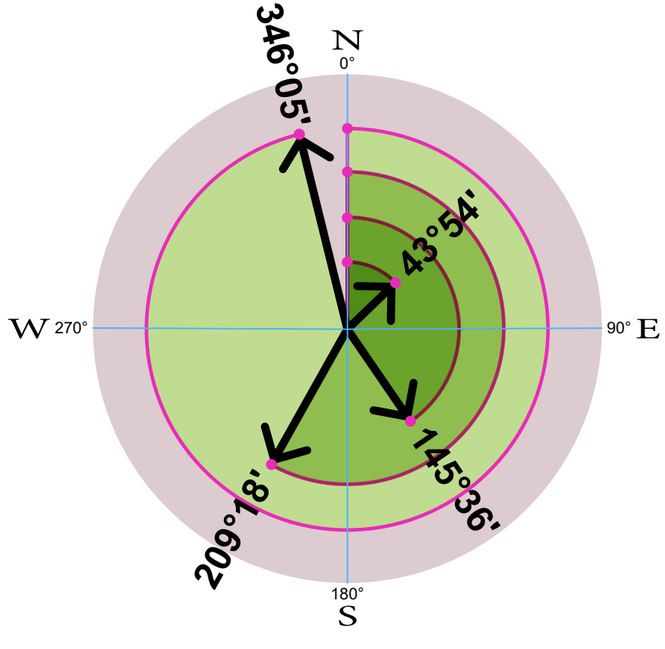
Bearings indicate direction

Bearings are most generally expressed as an angle measured either east or west of 0° north or 0° south. Bearings indicate a direction, or course of travel, for example, going from one point in a deed to the next point in the deed. They're typically expressed in degrees' minutes, and seconds.



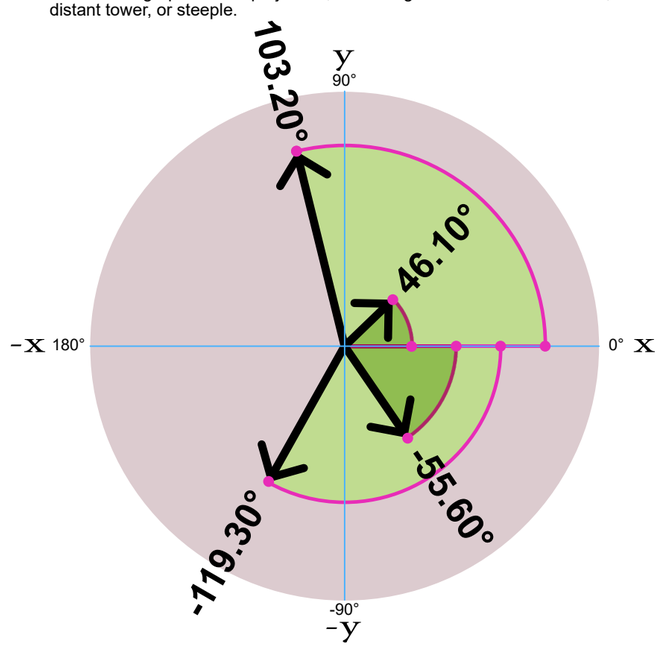
Azimuths indicate direction

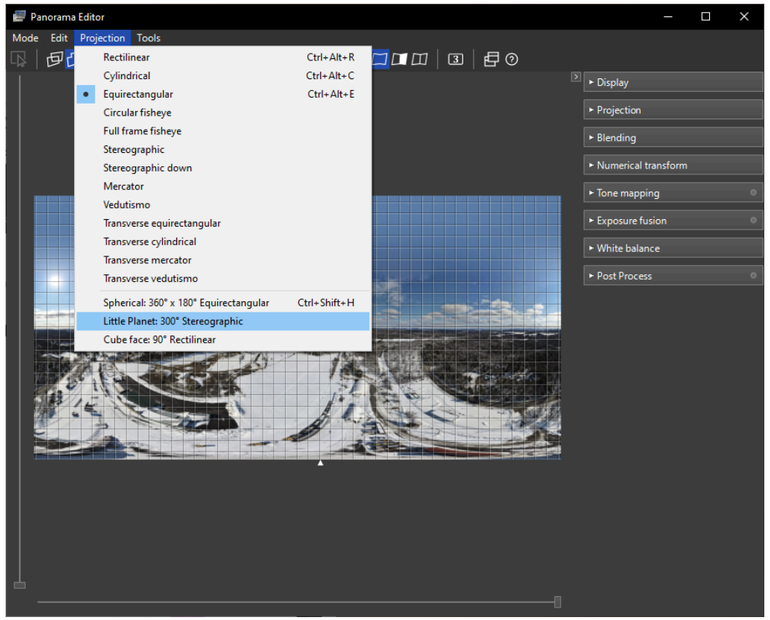
Azimuths are most generally expressed as an angle measured clockwise from 0° north, 0° to 360°. Azimuths indicate a direction, or course of travel, for example, a line of sight going from the observer to a known object. They're typically expressed in degrees, minutes, and seconds, or decimal degrees.



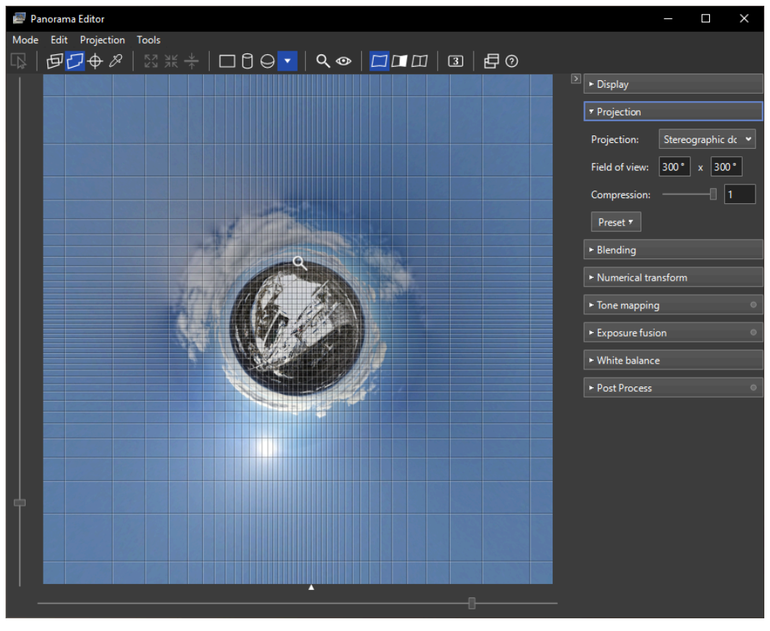
Polar rays indicate direction

Polar rays are generally expressed as an angle in decimal degrees measured about the pole (origin 0,0) from a reference direction of 0° on the x axis; a negative value measured clockwise; a positive value measured counterclockwise. For example, from the center of an image, like a stereographic down projection, to a recognized feature like the sun, distant tower, or steeple.

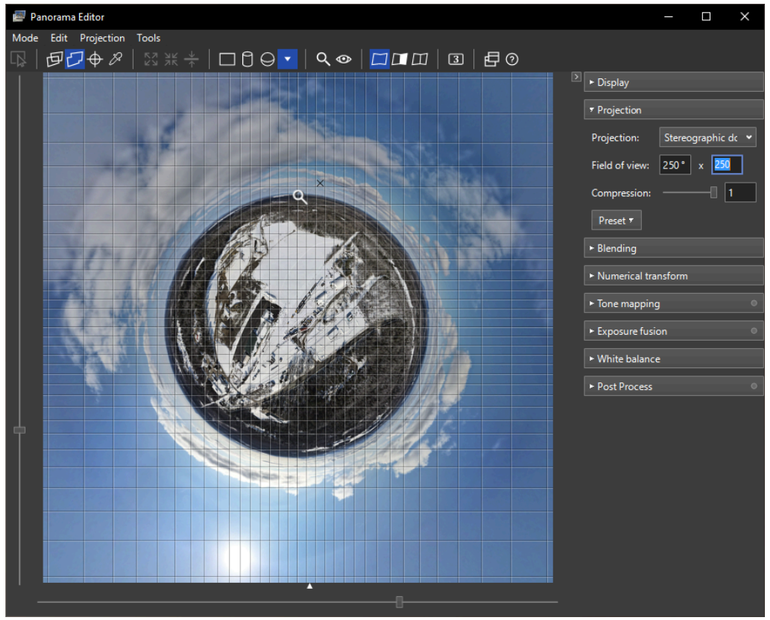




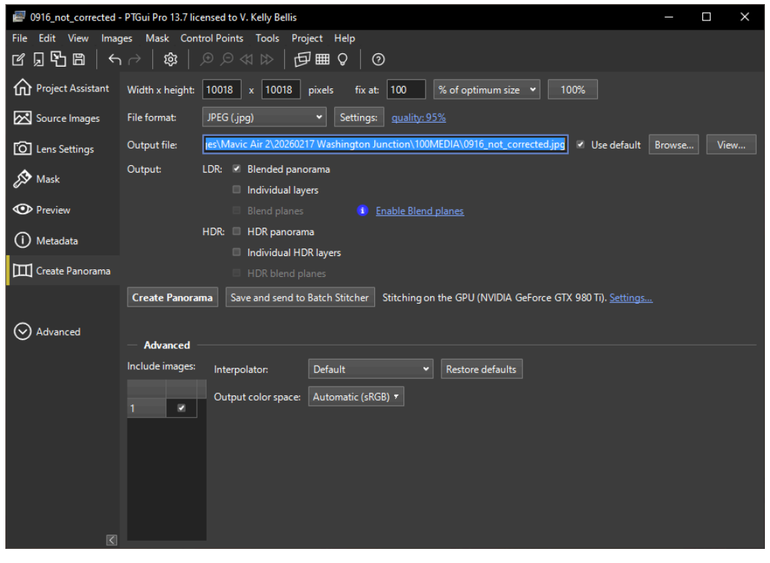
Open PTGui and load the equirectangular image into the Untitled.pts workspace. Ctrl+E, in the Panorama Editor, main menu Projection, choose *Little Planet: 300° Stereographic*.



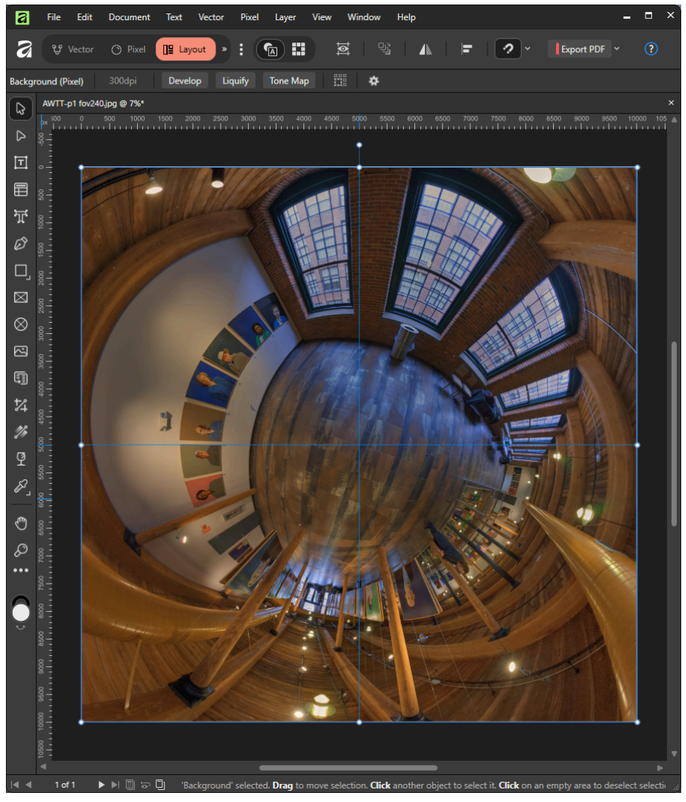
Mindful of what you had previously determined to use for your true north reference object, narrow the field of view to exclude the periphery while keeping aspect ratio x:y as 1:1; e.g., 250° x 250°.

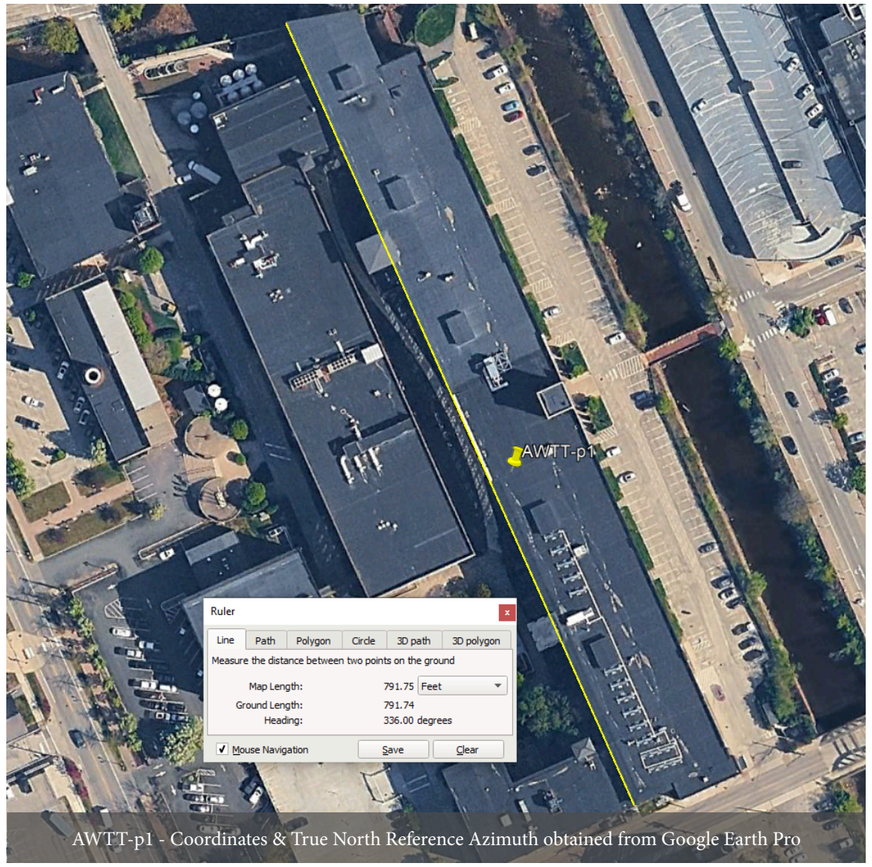


At this point, Ctrl+S, Save your project with some indication in the name that it's pre yaw correction; e.g., `0916_not_corrected`, and then Create Panorama. Export the image, but when finished with the export, leave PTGui open if you plan to immediately perform the calculations and the entry of the yaw correction value, otherwise, Save and close PTGui.


0916_not_corrected - PTGui Pro 13.7 licensed to V. Kelly Bellis
File Edit View Images Mask Control Points Tools Project Help
Project Assistant
Source Images
Lens Settings
Mask
Preview
Metadata
Create Panorama
Advanced
Width x height: 10018 x 10018 pixels fix at: 100 % of optimum size 100%
File format: JPEG (.jpg) Settings: quality:95%
Output file: es\Mavic Air 2\20260217 Washington Junction\100MEDIA\0916_not_corrected.jpg Use default Browse... View...
Output: LDR: Blended panorama
Individual layers
Blend planes Enable Blend planes
HDR: HDR panorama
Individual HDR layers
HDR blend planes
Create Panorama Save and send to Batch Stitcher Stitching on the GPU (NVIDIA GeForce GTX 980 Ti). Settings...
Advanced
Include images: Interpolator: Default Restore defaults
Output color space: Automatic (sRGB)

Define the origin for measuring polar angles using your favorite image editing software, Affinity, Adobe, etc. Load the stereographic projected image exported from PTGui. Make sure that snapping has been enabled, drag a horizontal guide and vertical guide to the center of the panorama. For the purposes of this discussion, both Photoshop and Affinity have been used, but the concepts presented here are equally applicable to other graphics programs.


File Edit Document Text Vector Pixel Layer View Window Help
Vector Pixel Layout Export PDF
Background (Pixel) 300dpi Develop Liquify Tone Map
AWTT-p1 fov240.jpg @ 7%*
1 of 1 'Background' selected. Drag to move selection. Click another object to select it. Click on an empty area to deselect selecti



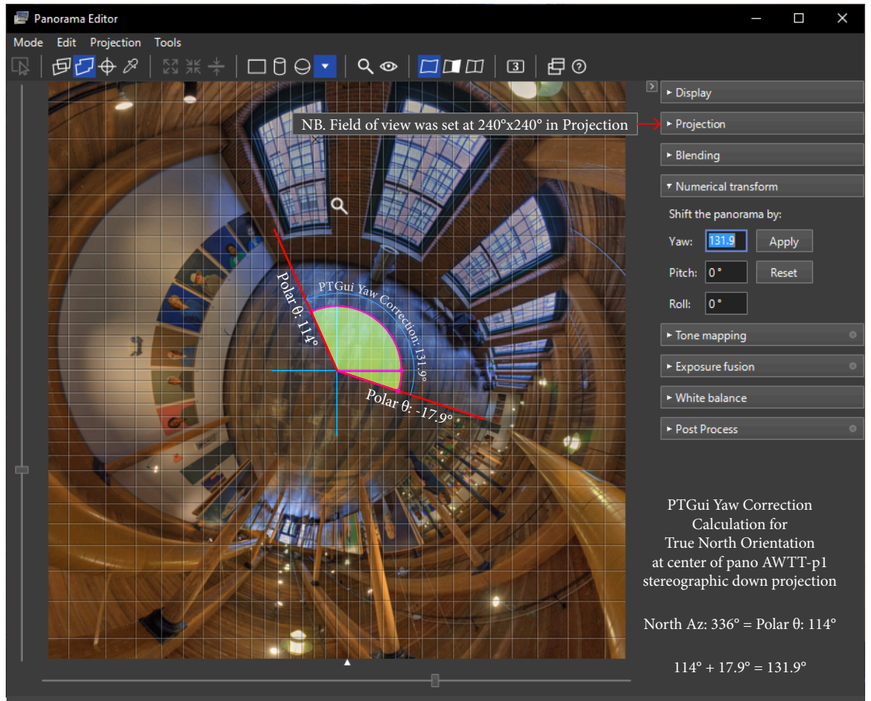
AWTT-p1 - Coordinates & True North Reference Azimuth obtained from Google Earth Pro

Scenario One - Orienting to true north inside of a building

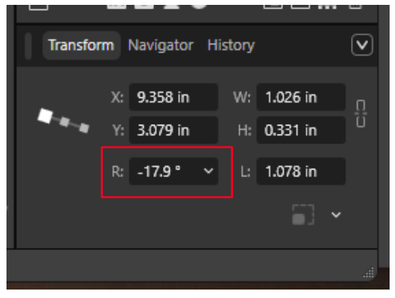
Defining the reference azimuth. Use Google Earth Pro, or any other geospatial program that allows you to measure true north azimuths. Google Earth Pro[1] is an excellent tool to use and it's free. After locating the subject building on the map in Google Earth Pro, using the Ruler tool, Line tab, place the cursor over one edge of the building, left click, then place the cursor over another position along the same edge of the building, and left click again. The Ruler, Line tab, display pane's Map Length and Ground Length values can be ignored, but take note of the value of the *Heading*. This reference azimuth will be your panorama's basis of orientation to true north.

Measuring the polar angle in your graphics program. Beginning at the point of origin, using the Pen Tool (P), position the cursor over it and left-click just once without dragging. Look for the best visual indicator ray that correlates with the defined reference azimuth. That best visual indicator ray may be parallel with the reference azimuth or perpendicular (orthogonal) as stereographic projections perfectly maintain correct angular relationships *radial from the origin*. That best visual indicator ray may also fall along the floor or the ceiling as they share the common vanishing point. If you're a student of perspective, those same vanishing points are also associated with the curving lines where each arc terminates.

[1] https://www.google.com/earth/about/versions/#download-pro



PTGui, Panorama Editor, Numerical transformation, Yaw Correction Calculation & Entry

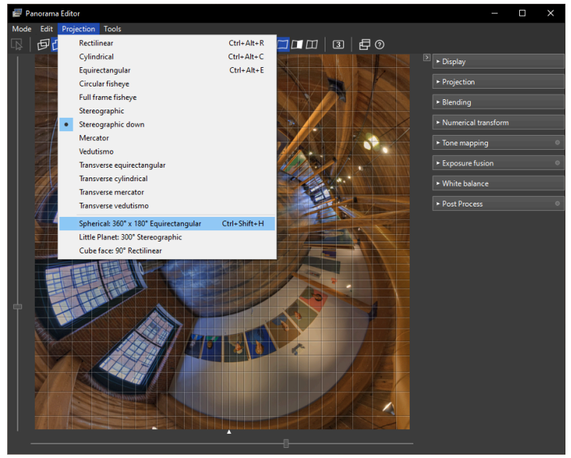


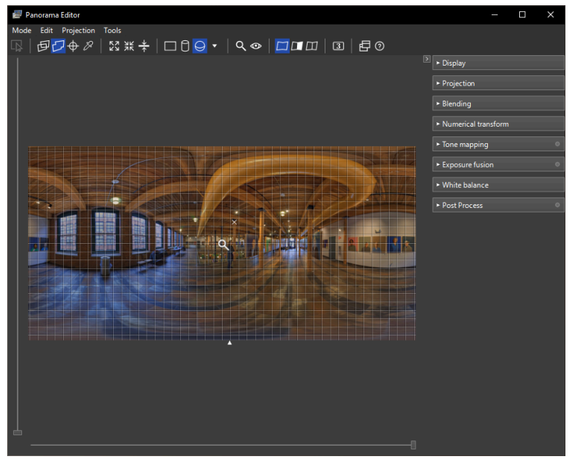
Place the cursor on the best visual indicator ray furthest from the origin. In Affinity, Vector, or Layout, thinly; e.g., 0.5 pt, Stroke this line, and change the layer's blend setting to multiply. When satisfied with the drawn ray, select it with the Move Tool (V), check the Transform panel - if not already open, enable it by Window, General, Transform. The only bit of information you seek is the rotation value, R:, the polar angle. Default decimal values can be changed if desired, Edit, Settings, User Preferences, Decimal Places, Degrees.

APPLIES TO ALL SCENARIOS - The calculation of the value to use for the panorama's yaw correction in PTGui is simple, though it is greatly benefited if you make a little sketch to determine its angle and direction. See AWTT-p1 (above and on the next page) as an example calculation and entry into PTGui, Panorama Editor, Numerical transform, Yaw:.

Once the yaw correction has been entered into PTGui, Panorama Editor, Numerical transform, Yaw:, click on Apply, and then Ctrl+Shift+S, Save Project As..., naming it with some indication that it's yaw correction and its yaw correction value have been applied; e.g., `AWTT-p1_with_yaw_correction_131,9.pts` - Then click Reset to clear the value in the Yaw: field.

Still in PTGui, Panorama Editor, Projection, return to your preferred and final intended panorama projection; e.g., *Spherical: 360° x 180° Equirectangular*. Save & you're done!





Scenario Two
Orienting to true north using the sun

Where. If your panorama includes the sun, performing a solar calculation will require an estimation of your geographic position. Again, Google Earth Pro is an excellent tool to use, but so are any number of free options available to you including your cell phone.

When. The precision of your estimated position is not as critical as that of the *time* when the sun was photographed. If your camera's system time has been recently, or is automatically updated, then you should be all set; otherwise, compare the camera's system time with the current time, making note of any time differences and adjusting before entry of the data into the solar calculator.

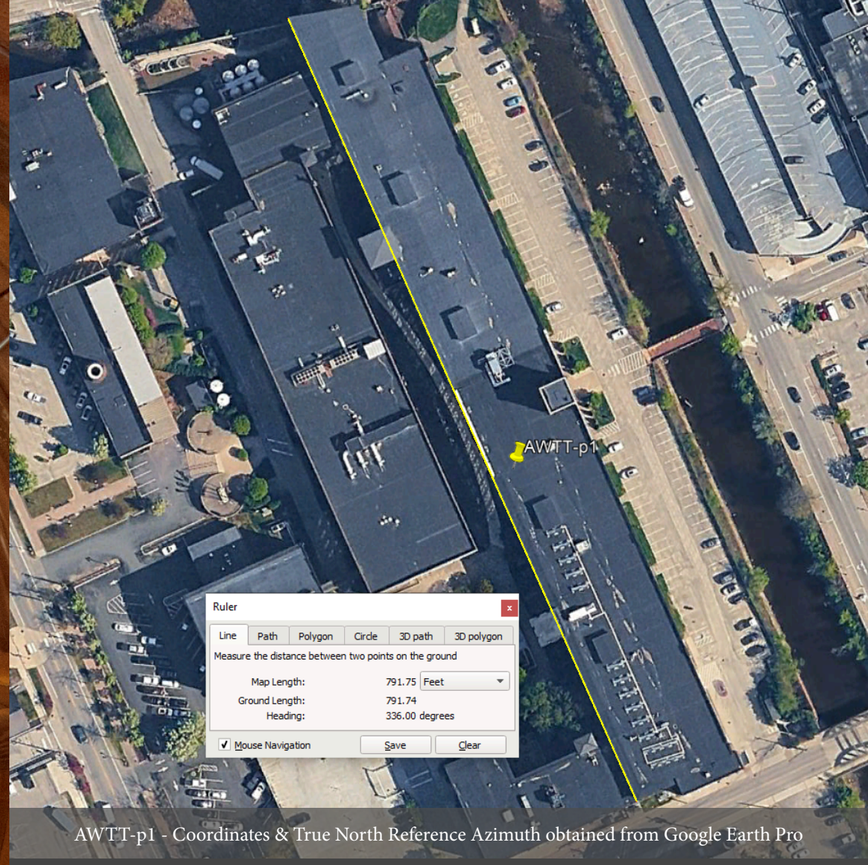
AWTT-p1 Oriented to True North

- ***WGS84 geographic coordinate determinations***
  Station AWTT-p1: *Approximated position using Google Earth Pro*
  https://www.google.com/earth/about/versions/#download-pro

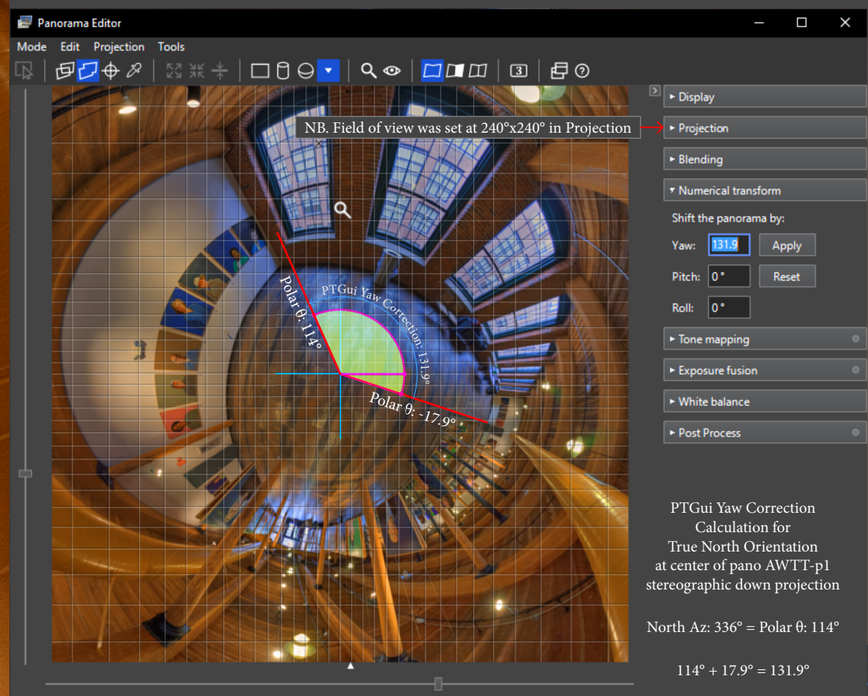
- ***Azimuth calculations***
  Primary Az calculated: *Direct measurement using Google Earth Pro*

- ***Polar θ measurements***
  Polar θ: measured after PTGui yaw correction: 131.9°, had been applied for pano AWTT-p1

Primary Az: 336.00°
Polar θ: 114.04 86 60
Az: 66.00°
Polar θ: 23.91 61 73 0
Pano origin
AWTT-p1:
44.094511°
-70.218232°
Americans Who Tell the Truth Exhibit, Lewiston, Maine
Building footprint used for orientation
Yaw correction used for pano AWTT-p1: 131.9°
Photograph Date & Time: 9 Dec 2024, 12:07:29 UTC-5



AWTT-p1 - Coordinates & True North Reference Azimuth obtained from Google Earth Pro

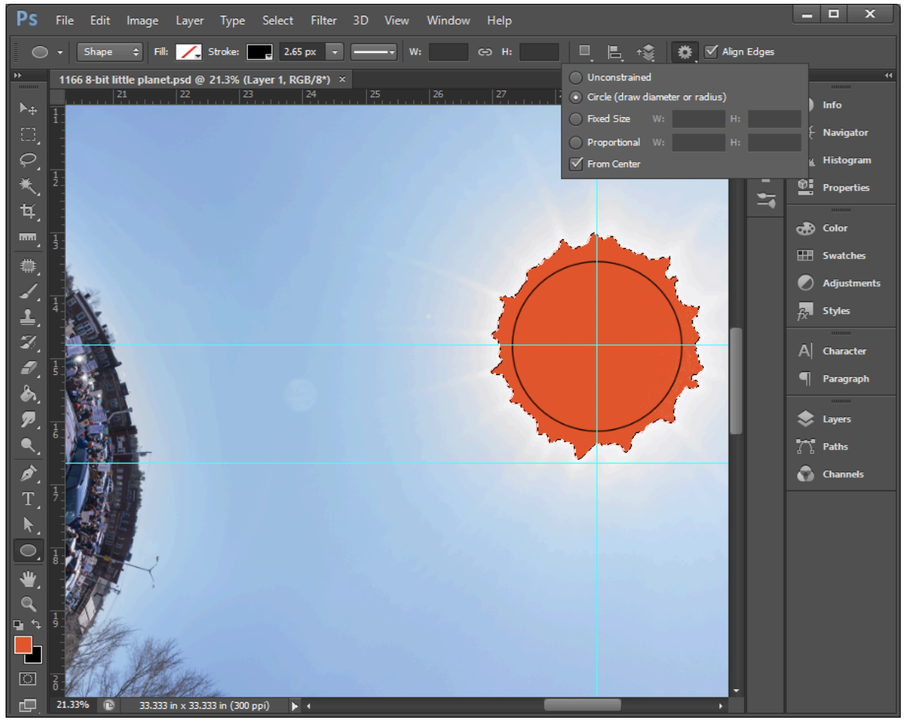


PTGui Yaw Correction
Calculation for
True North Orientation
at center of pano AWTT-p1
stereographic down projection

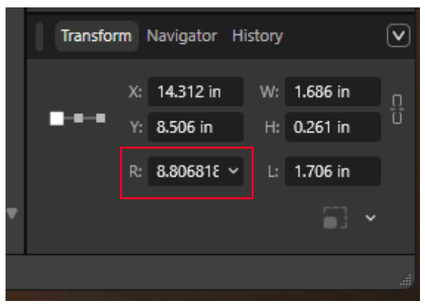
North Az: 336° = Polar θ: 114°

114° + 17.9° = 131.9°

PTGui, Panorama Editor, Numerical transformation, Yaw Correction Calculation & Entry



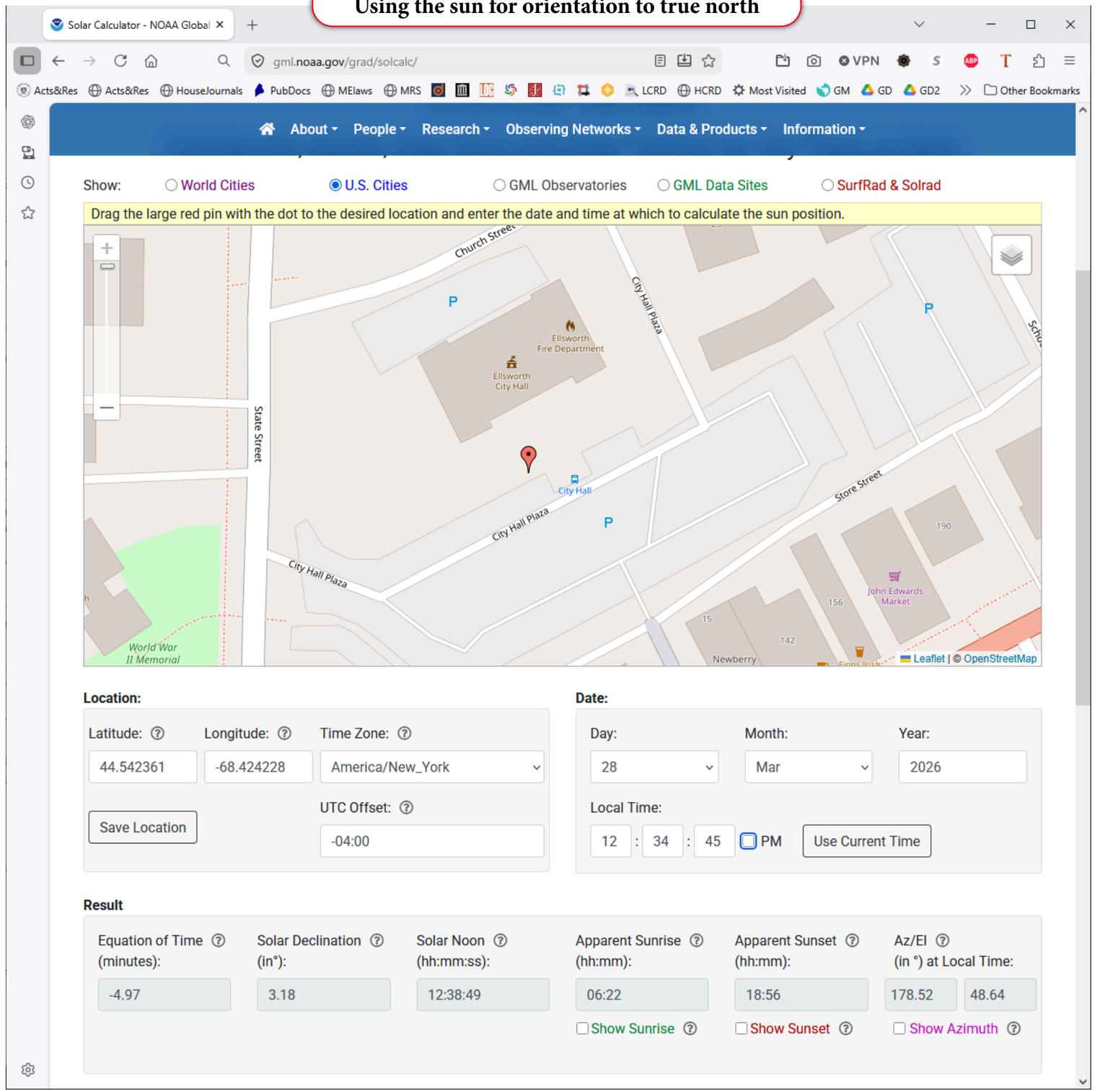
Defining the center of the sun. The last thing that you'll need to estimate is the center of the sun in the *stereographic projected image*. Using a very low Tolerance setting in the Flood Select Tool (W) in Affinity, Pixel, or the Wand Tool (W) in Photoshop, select the blown out area approximating the sun, create a new layer, and fill it with the Fill Tool (G). Snapping to the center of the filled layer, this provides an excellent starting point to holding down both the Ctrl and Shift keys (Affinity), drag and draw a circle with Ellipse Tool (U). Using the Move Tool (V) adjust the position of the circle before dragging horizontal and vertical guides for the center of the sun.



Measuring the polar angle with Affinity. Beginning at the *point of origin*, using the Pen Tool (P), position the cursor over it and left-click just once without dragging, followed by a left-click on the center of the sun. In Affinity, Vector, or Layout, thinly; e.g., 0.5 pt, Stroke this line, and change the layer's blend setting to multiply. When satisfied with the drawn ray, select it with the Move Tool (V), check the Transform panel - if not already open, enable it by Window, General, Transform. The only bit of information you seek is the rotation value, R:, the polar angle. Default decimal values can be changed if desired, Edit, Settings, User Preferences, Decimal Places, Degrees. The Ruler Tool in Photoshop can also be used to measure the polar angle.

Defining the reference azimuth. For the purposes of this discussion, I've used the NOAA Solar Calculator https://gml.noaa.gov/grad/solcalc/, though note that in the wake of Federal funding cuts to NOAA, as of the first week in August 2025, the Solar Calculator is no longer

Using the sun for orientation to true north

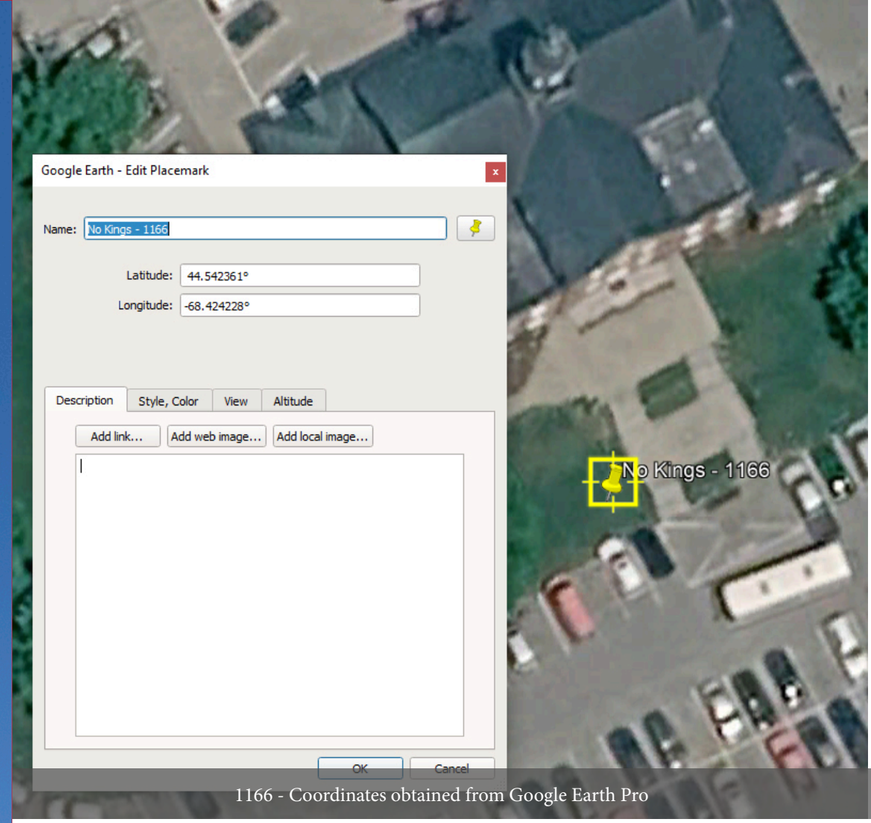


1166 Oriented to True North

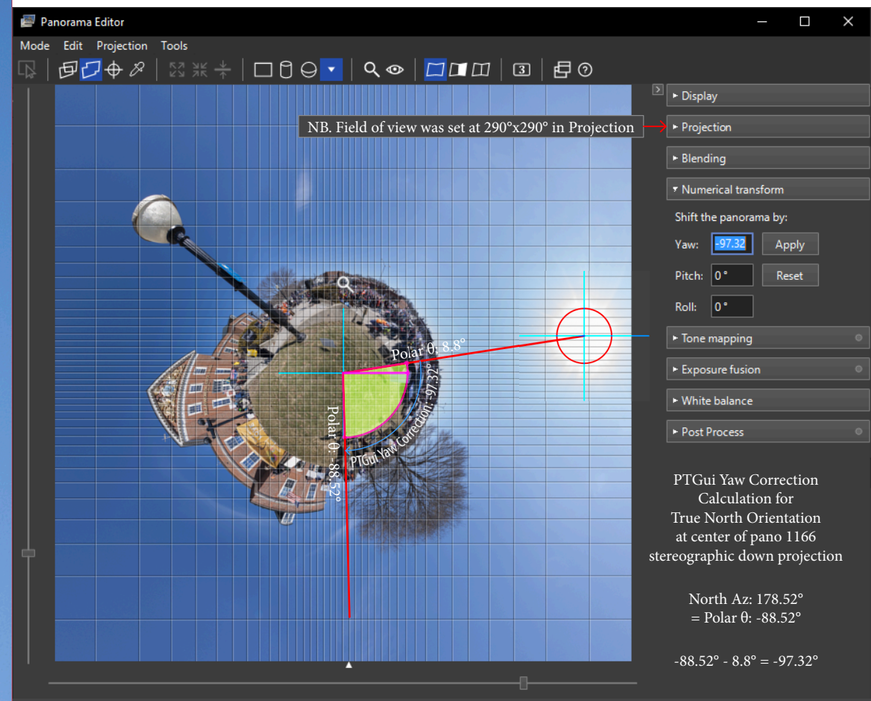
- ***WGS84 geographic coordinate determinations***
  Station 1166: *Approximated position using Google Earth Pro*
  https://www.google.com/earth/about/versions/#download-pro

- ***Azimuth calculations***
  1166 to Sol Az calculated at: *https://gml.noaa.gov/grad/solcalc/*

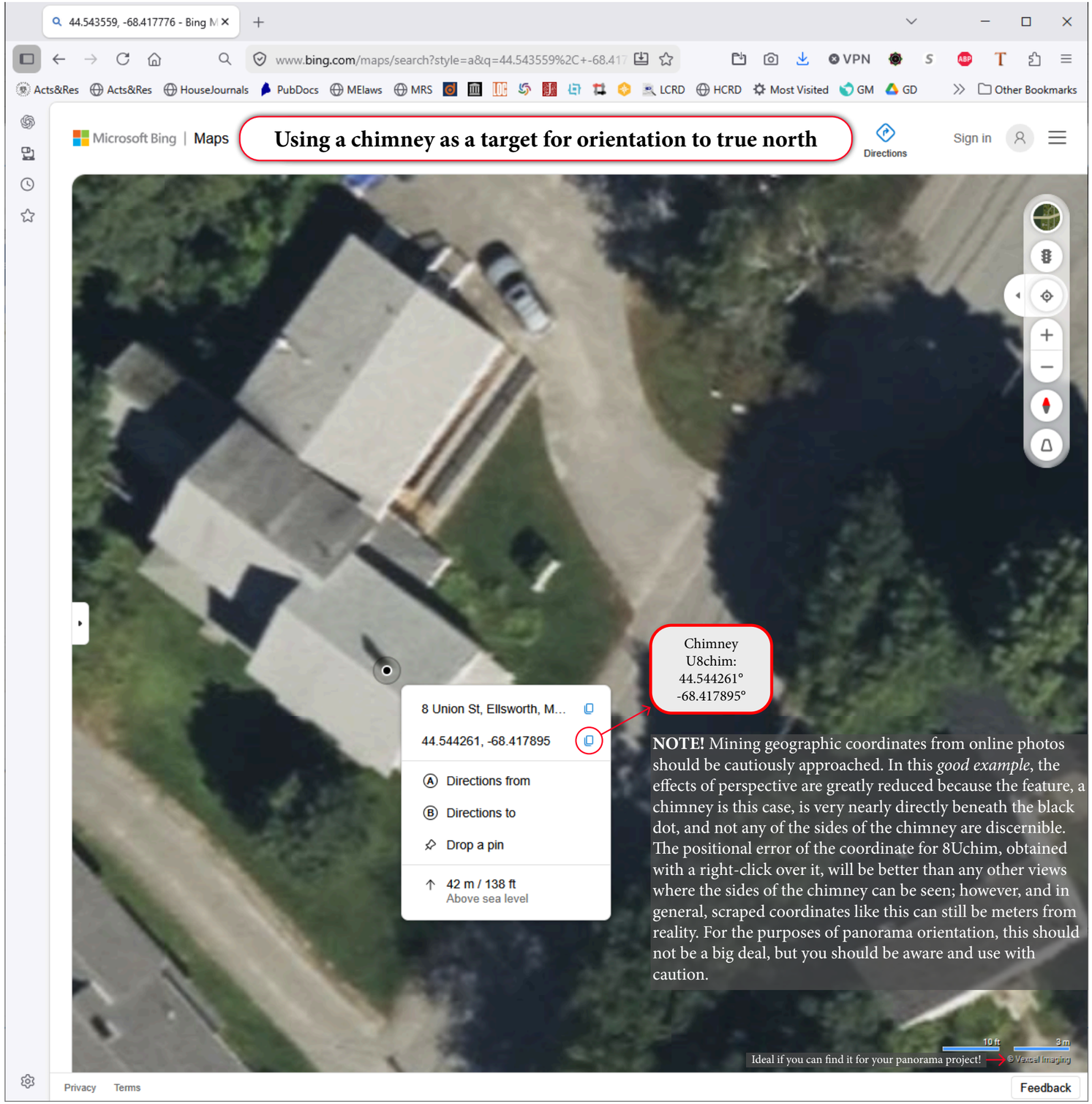
- ***Polar θ measurements***
  Polar θ: measured after PTGui yaw correction: -97.32°, had been applied for pano 1166

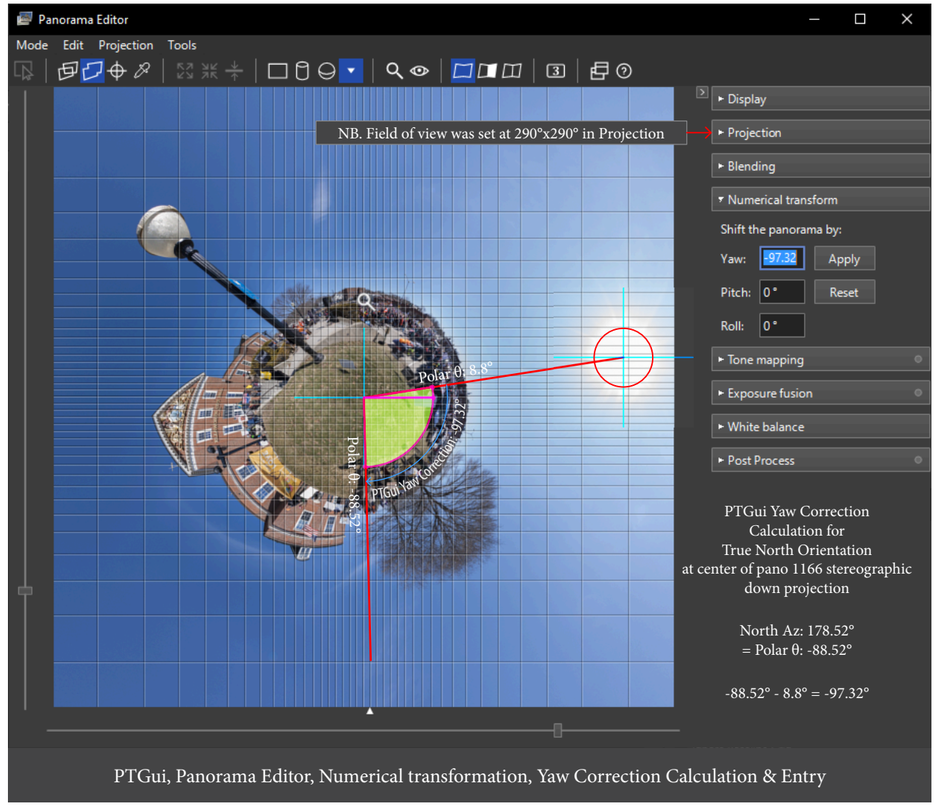


1166 - Coordinates obtained from Google Earth Pro



PTGui, Panorama Editor, Numerical transformation, Yaw Correction Calculation & Entry


44.543559, -68.417776 - Bing M
www.bing.com/maps/search?style=a&q=44.543559%2C+-68.417
Microsoft Bing | Maps
Using a chimney as a target for orientation to true north
Directions
Sign in
8 Union St, Ellsworth, M...
44.544261, -68.417895
Directions from
Directions to
Drop a pin
42 m / 138 ft
Above sea level
Chimney
U8chim:
44.544261°
-68.417895°
NOTE! Mining geographic coordinates from online photos should be cautiously approached. In this good example, the effects of perspective are greatly reduced because the feature, a chimney is this case, is very nearly directly beneath the black dot, and not any of the sides of the chimney are discernible. The positional error of the coordinate for 8Uchim, obtained with a right-click over it, will be better than any other views where the sides of the chimney can be seen; however, and in general, scraped coordinates like this can still be meters from reality. For the purposes of panorama orientation, this should not be a big deal, but you should be aware and use with caution.
Ideal if you can find it for your panorama project!
10 ft
3 m
© Vexcel Imaging
Privacy
Terms
Feedback



PTGui, Panorama Editor, Numerical transformation, Yaw Correction Calculation & Entry

being actively supported or maintained. See above example solar calculation for 1166 and its application in calculating and entering the yaw correction into PTGui.

Scenario Three
Orienting to true north using a cell tower, or other known feature

The use of the sun in determination of the reference azimuth may not always be convenient for any number of reasons including time of day, cloud cover, or in the case of photo datasets captured with a drone, the gimbal can't look up high enough to see the sun. That situation is often the case in middle latitudes when shooting between the Vernal Equinox and Autumnal Equinox. One workaround when the sun isn't a viable means for the determination of the reference azimuth, is to use any recognized feature that is discernible in the panorama that has a known geographic position.

Where. Performing these sorts of calculations will require an estimation of your occupied station's geographic position. Once again, Google Earth Pro is an excellent tool to use, but so are any number of free options available to you including your cell phone. Averaged drone coordinates from the entire dataset are also fine to use.

Choosing your target. In general, the further from your occupied station; i.e., your panorama's center, to your target, the better, because longer foresights can help to mitigate (to varying degrees), a variety of errors.

Identifying the correct tower. Cell Towers and other transmission structures are fairly common place, so much so that it may not be easy to correctly identify which structure you're considering to use for orienting your panorama to true north. Identifying the correct tower, and moreover getting the correct coordinates for its geographic position, is essential for orienting your panorama to true north.

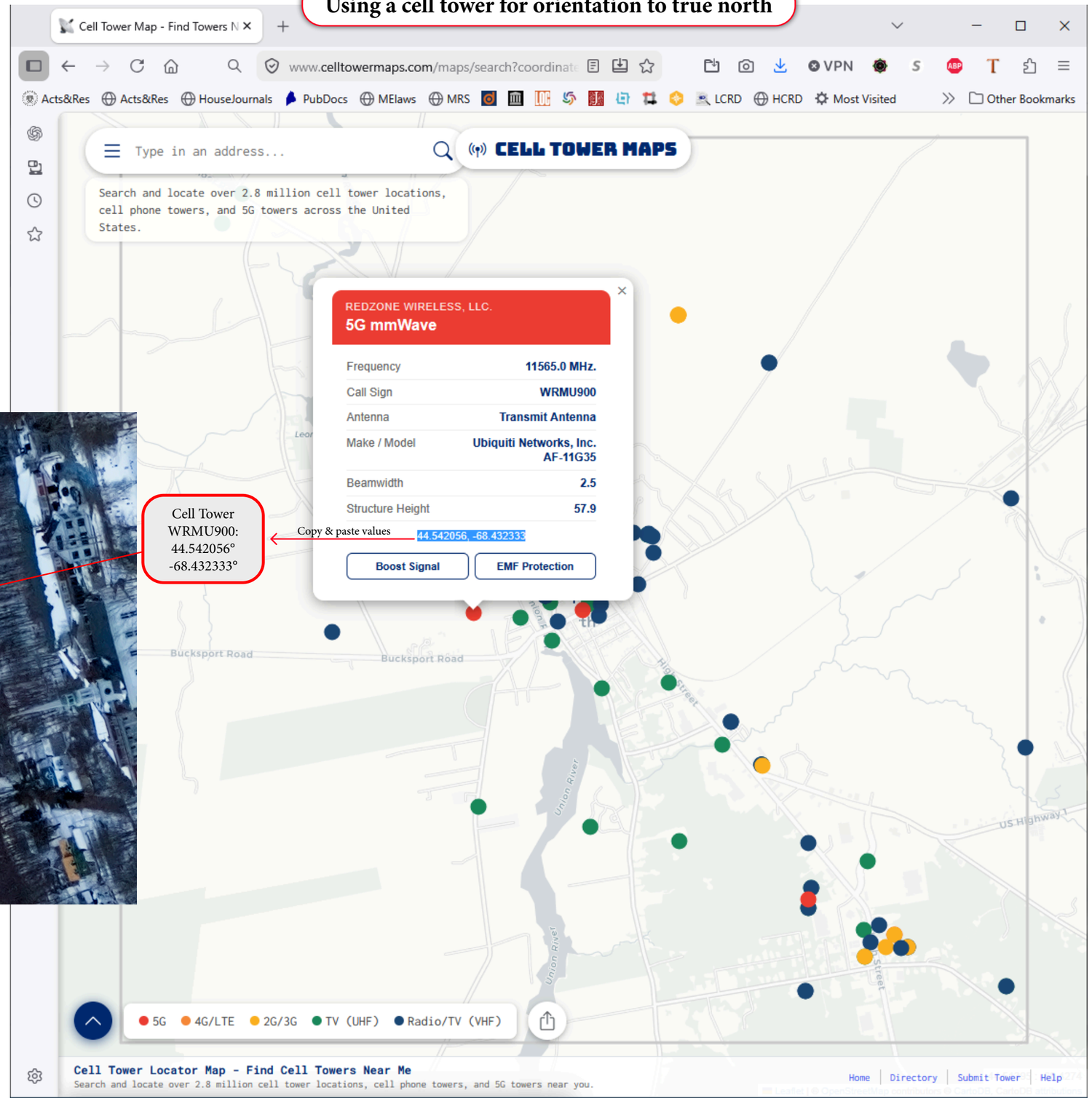
There are multiple apps and online resources that can help to identify the structure including this example, https://www.celltowermaps.com, shown here on the right. The first thing to note is the *Structure Height*, 57.9 meters (190 feet) and that it is visible in the pano above the horizon. Dataset 0951 was flown at an altitude of 50.8 meters above the home point, the point from where the drone had been launched. If the heights of the drone and subject tower had been reversed, the cell tower wouldn't be as easily noticed. Just as an example, not unlike WRMU900's nearby neighbor, a shorter unidentified microwave tower that's nearly impossible to see in this snippet from the stereographic image - see it on the left edge of the aerial imagery below.

Also, consider checking the coordinate given by these types of online sources. The coordinate value should be nearly the same; e.g., https://www.antennasearch.com, Google Earth Pro, https://www.bing.com/maps, etc.; otherwise, large differences may indicate to use additional caution.

Note that the black dot in the above image on the left, has been placed at the base of tower, not the top of the tower, and that it is also coincident with the tower's shadow thus ensuring a ground coordinate. Note to students of perspective, all vertical lines in a stereographic projection converge at the origin, and center of the panorama in these very unique 3-point perspectives.

Another reason to use caution in mining coordinates for these types of reference objects, is the general rate of proliferation of towers and the staleness of aerial imagery. For example, the tower that clearly appears in your panorama may not be shown on Bing Maps, but is shown on Google Earth Pro; likewise, don't expect that online services like https://www.antennasearch.com and https://www.celltowermaps.com are always updated at the same time.

Using a cell tower for orientation to true north



0951 Oriented to True North

- ***WGS84 geographic coordinate determinations***
  Station 0951: *Averaged from 26 images in dataset*
  Station 8uchim: *https://www.bing.com/maps?cp=44.544227%7E-68.417813&lvl=21.9&style=h*
  Station WMRU900: *https://www.celltowermaps.com/?address=17+Union+Street%2C+Ellsworth%2C+ME+04605%2C+United+States+of+America*

- ***Azimuth calculations***
  0951 to Sol Az calculated at: *https://gml.noaa.gov/grad/solcalc/*
  0951 to U8chim Az calculated at: *https://walter.bislins.ch/bloge/index.asp?page=WGS84+Distance%2C+Azimuth+and+Radius+Calculator*
  0951 to WMRU900 Az calculated at: *https://walter.bislins.ch/bloge/index.asp?page=WGS84+Distance%2C+Azimuth+and+Radius+Calculator*

- ***Polar θ measurements***
  Polar θ: measured after PTGui yaw correction: -3.13°, had been applied for pano 0951 (calculated from SolAz using the GimbalYawDegree predicate dataset)

Defining the reference azimuth. For the purposes of this discussion, I've used the online calculator generously maintained and offered by Walter Bislins at his website: https://walter.bislins.ch/bloge/index.asp?page=WGS84+Distance%2C+Azimuth+and+Radius+Calculator

While preparing this tutorial, I looked at several online calculators and found Mr. Bislin's the best suited for the calculation of a reference azimuth oriented to true north, it's well laid out, and easiest to use. Just enter the coordinates of the center of the panorama in section Position 1, and the coordinates of reference object in section Position 2, being sure to complete field entry by pressing enter or tabbing to the next field.

- ***Example dataset used: 0951***
- *Center of panorama averaged from all 26 images:*
  44.54455543°, -68.41719148°
- *Reference object: 8Uchim:*
  44.544261, -68.417895
- *WGS84 Inverse 0951 to 8Uchim:*
  Geodetic Reference Azimuth: 239.66° True North
  Geodetic Distance: 64.78 meters

About the Cover Panorama 0979

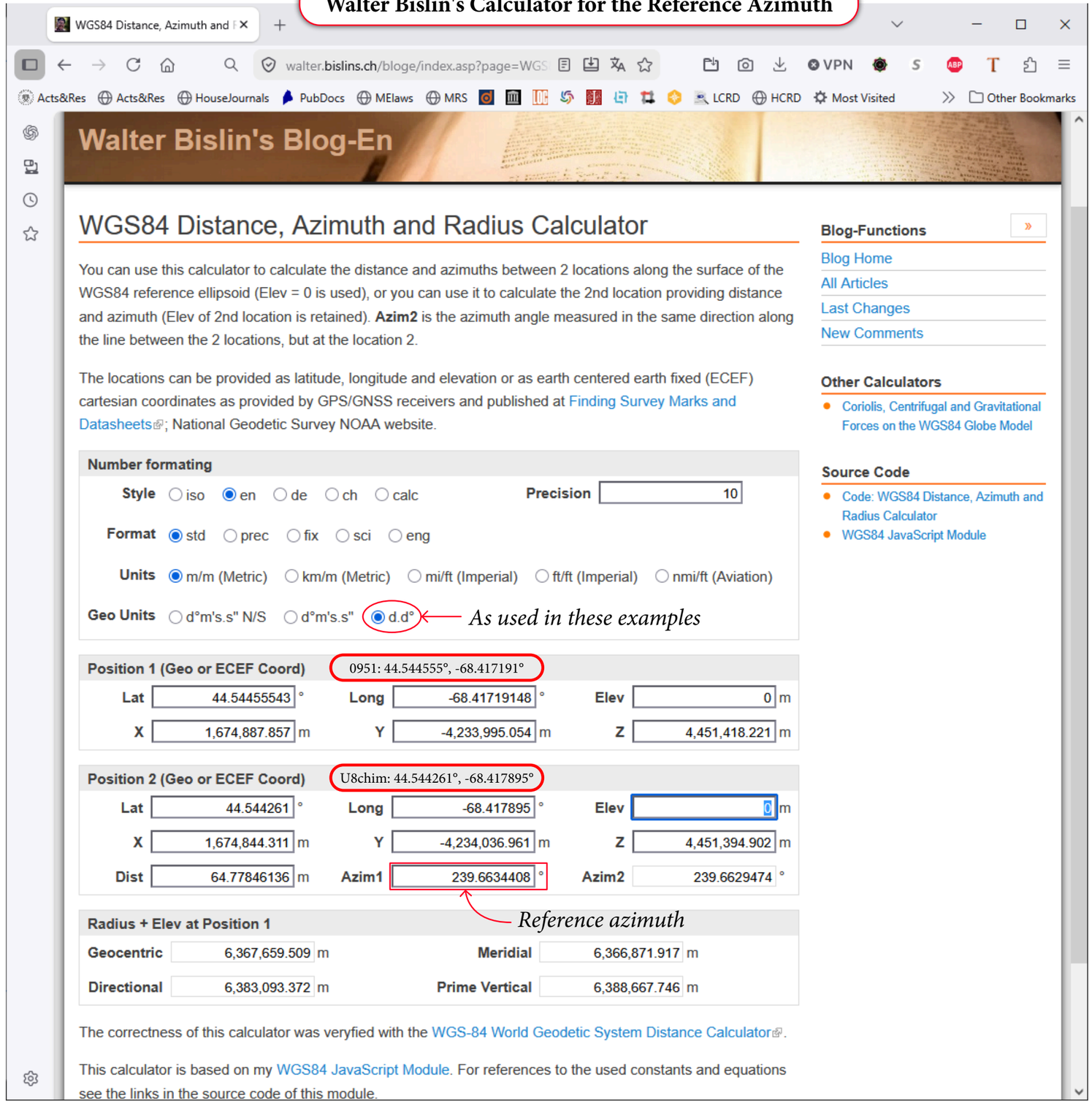
Panorama 0979 is shown on the front cover after its yaw correction of 23.71° had been applied in PTGui. The reference azimuth that had been used to orient the panorama to true north was based on the calculated azimuth to the cell tower WMRU900, Foresight ID [5]. To independently verify its value, 8 other geodetic azimuths were calculated and then compared with their panorama azimuths. The differences between the calculated azimuths and the panorama azimuths are listed in the column headed Caz-Paz in the spreadsheet below.

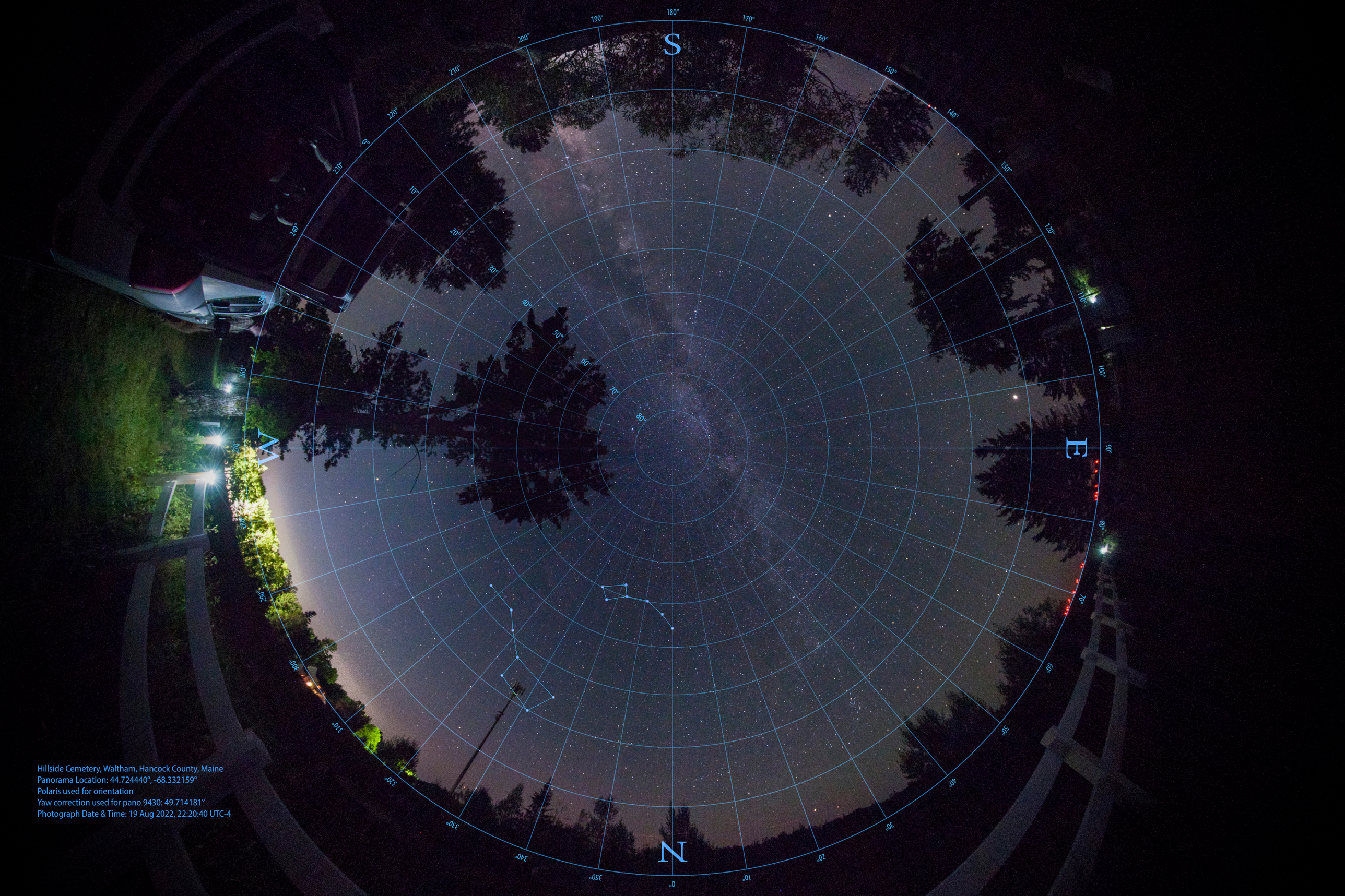
When interpreting these results, keep in mind the following: 1) reasonable error allowances; 2) none of the coordinates have actually been surveyed using survey-grade GNSS equipment; 3) all coordinates have either been scraped from online sources, averaged from autonomous consumer-grade single frequency GNSS devices, or in the cases of the cell tower data, published positions that are based on unknown methods; and 4) how well we can measure polar angles from the stereographic projections in the raster images produced by PTGui.

ON THE COVER – PANORAMA 0979 - WGS84

OCC	FS ID	FS Name	Lat	Lon	Calc Az	Distance m	Polar ∠	Pano Az	Caz-Paz	Date & Time
0979	0		44.542765	-68.420040						
0979	1	Sol			119.840000		-29.643349	119.643349	0.196651	2026:03:04 08:02:30
0979	2	KNKN923	44.521417	-68.394528	139.467412	3121.872	-49.203724	139.203724	0.263688	
0979	3	1326028	44.519759	-68.392843	139.772834	3347.985	-49.532625	139.532625	0.240209	
0979	4	WQSA315	44.524389	-68.401972	144.913806	2498.807	-54.691854	144.691854	0.221952	
0979	5	WRMU900	44.542056	-68.432333	265.392336	980.161	-175.327491	265.327491	0.064845	Reference Azimuth
0979	6	WML583	44.547111	-68.511194	273.845942	7259.985	176.346945	273.653055	0.192887	
0979	7	1stCongo	44.543017	-68.424725	274.290367	373.368	175.553664	274.446336	-0.155969	
0979	8	EHSwater	44.555056	-68.425841	341.350539	1441.492	108.700224	341.299776	0.050763	
0979	9	8Uchim	44.544261	-68.417895	45.715829	238.058	43.874597	46.125403	-0.409574	
								AVERAGE	0.073939	
								STDEV	0.224173	

Walter Bislin's Calculator for the Reference Azimuth


WGS84 Distance, Azimuth and
walter.bislins.ch/bloge/index.asp?page=WGS
Walter Bislin's Blog-En
WGS84 Distance, Azimuth and Radius Calculator
You can use this calculator to calculate the distance and azimuths between 2 locations along the surface of the WGS84 reference ellipsoid (Elev = 0 is used), or you can use it to calculate the 2nd location providing distance and azimuth (Elev of 2nd location is retained). Azim2 is the azimuth angle measured in the same direction along the line between the 2 locations, but at the location 2.
The locations can be provided as latitude, longitude and elevation or as earth centered earth fixed (ECEF) cartesian coordinates as provided by GPS/GNSS receivers and published at Finding Survey Marks and Datasheets; National Geodetic Survey NOAA website.
Number formating
Style iso en de ch calc
Precision 10
Format std prec fix sci eng
Units m/m (Metric) km/m (Metric) mi/ft (Imperial) ft/ft (Imperial) nmi/ft (Aviation)
Geo Units d°m's.s" N/S d°m's.s" d.d°
As used in these examples
Position 1 (Geo or ECEF Coord)
0951: 44.544555°, -68.417191°
Lat 44.54455543 ° Long -68.41719148 ° Elev 0 m
X 1,674,887.857 m Y -4,233,995.054 m Z 4,451,418.221 m
Position 2 (Geo or ECEF Coord)
U8chim: 44.544261°, -68.417895°
Lat 44.544261 ° Long -68.417895 ° Elev 0 m
X 1,674,844.311 m Y -4,234,036.961 m Z 4,451,394.902 m
Dist 64.77846136 m Azim1 239.6634408 ° Azim2 239.6629474 °
Reference azimuth
Radius + Elev at Position 1
Geocentric 6,367,659.509 m Meridial 6,366,871.917 m
Directional 6,383,093.372 m Prime Vertical 6,388,667.746 m
The correctness of this calculator was veryfied with the WGS-84 World Geodetic System Distance Calculator.
This calculator is based on my WGS84 JavaScript Module. For references to the used constants and equations see the links in the source code of this module.
Blog-Functions
Blog Home
All Articles
Last Changes
New Comments
Other Calculators
Coriolis, Centrifugal and Gravitational Forces on the WGS84 Globe Model
Source Code
Code: WGS84 Distance, Azimuth and Radius Calculator
WGS84 JavaScript Module



Hillside Cemetery, Waltham, Hancock County, Maine
Panorama Location: 44.724440°, -68.332159°
Polaris used for orientation
Yaw correction used for pano 9430: 49.714181°
Photograph Date & Time: 19 Aug 2022, 22:20:40 UTC-4